

**AMENDMENTS TO THE CLAIMS**

1           1.       (Currently amended) An estimation method for estimating illumination on  
2       a sensor capable of capturing non-destructively a plurality of image samples during an  
3       exposure period, said method comprising the steps of:

4           measuring an illumination indication from said sensor, said measuring occurs a  
5       multiplicity of two or more times at intervals during said exposure period, ~~thereby~~  
6       producing a multiplicity of measurements; and

7           determining, based on an optimal weighted averaging process, an estimated  
8       illumination on said sensor from said multiplicity of measurements.

1           2.       (Original) The estimation method of claim 1, wherein said sensor is a  
2       photodiode and said illumination indication is a charge accumulated from photocurrent  
3       produced by said photodiode.

1           3.       (Original) The estimation method of claim 2, wherein said measuring step  
2       occurring non-destructively and said charge accumulating over said exposure period.

1           4.       (Original) The estimation method of claim 1, wherein said determining  
2       step including statistical signal processing of said multiplicity of measurements, said  
3       signal processing being based on a noise model selected from a fixed pattern noise  
4       model, a reset noise model, a shot noise model and a read noise model.

1           5.       (Original) The estimation method of claim 1, wherein said determining  
2       step including statistical signal processing of said multiplicity of measurements, said  
3       signal processing being based on maximizing a likelihood of accuracy of said estimated  
4       illumination.

1           6.       (Original) The estimation method of claim 1, wherein said determining  
2       step including statistical signal processing of said multiplicity of measurements, said  
3       signal processing being based on minimizing an error of said estimated illumination.

1           7.       (Original) The estimation method of claim 1, wherein said determining  
2 step including statistical signal processing of said multiplicity of measurements, said  
3 signal processing being based on minimizing a linear mean square error of said estimated  
4 illumination.

1           8.       (Original) The estimation method of claim 1, wherein said sensor is  
2 configured in a sensor array, a pixel sensor in a digital camera, a pixel sensor in a video  
3 camera, a pixel sensor in a stereo digital camera or a pixel sensor in a stereo video  
4 camera.

1           9.       (Currently amended) An estimation method for non-recursively estimating  
2 an optimal illumination on a sensor capable of capturing non-destructively a plurality of  
3 image samples during an exposure period, said method comprising the steps of:  
4           measuring an illumination indication from said sensor;  
5           storing said illumination indication, wherein said measuring and storing steps  
6 occur ~~a multiplicity of two or more~~ times during said exposure period, ~~thereby~~  
7 collecting non-destructively a multiplicity of measurements; and  
8           performing a non-recursive optimal illumination estimation on said sensor from  
9 all or essentially all of said collected multiplicity of measurements.

1           36.      (Previously presented) The estimation method of claim 9, wherein said  
2 determining step comprising statistical signal processing of said multiplicity of  
3 measurements, said signal processing being based on a noise model selected from a fixed  
4 pattern noise model, a reset noise model, a shot noise model and a read noise model.

1           10.      (Original) The estimation method of claim 9, wherein said sensor is a  
2 photodiode and said illumination indication is a charge accumulated from photocurrent  
3 produced by said photodiode.

1           11.     (Original) The estimation method of claim 10, wherein said measuring  
2     step occurring non-destructively and said charge accumulating over said exposure period.

3           12.     (Original) The estimation method of claim 9, wherein said determining  
4     step including statistical signal processing of said multiplicity of measurements, said  
5     signal processing being based on maximizing a likelihood of accuracy of said estimated  
6     illumination.

1           13.     (Original) The estimation method of claim 9, wherein said determining  
2     step further comprising statistical signal processing of said multiplicity of measurements,  
3     said signal processing being based on minimizing an error of said estimated illumination.

1           14.     (Original) The estimation method of claim 9, wherein said determining  
2     step further comprising statistical signal processing of said multiplicity of measurements,  
3     said signal processing being based on minimizing a linear mean square error of said  
4     estimated illumination.

1           15.     (Original) The estimation method of claim 9, wherein said sensor is  
2     configured in a sensor array, a pixel sensor in a digital camera, a pixel sensor in a video  
3     camera, a pixel sensor in a stereo digital camera or a pixel sensor in a stereo video  
4     camera.

1           16.     (Currently amended) An estimation method for recursively estimating an  
2     optimal illumination on a sensor capable of capturing non-destructively a plurality of  
3     image samples during an exposure period, said method comprising the steps of:  
4         measuring an illumination indication from said sensor, said measuring occurs a  
5     multiplicity of two or more times at intervals during said exposure period, ~~thereby~~  
6     producing a multiplicity of measurements; and

7 determining an estimated illumination on said sensor from all or essentially all of  
8 said multiplicity of measurements non-destructively captured before motion/saturation,  
9 said determining step occurring recursively over said multiplicity of measurements and  
10 including statistical signal processing of said multiplicity of measurements, said signal  
11 processing being based on a noise model selected from a fixed pattern noise model, a  
12 reset noise model, a shot noise model and a read noise model.

1 17. (Currently amended) The estimation method of claim 16 further  
2 comprising a step of maintaining a plurality of parameters during said measuring step,  
3 said plurality of parameters comprising:  
4 said estimated illumination;  
5 means for ~~weighting~~ weighing a particular one of said multiplicity of  
6 measurements;  
7 means for indicating variance between said particular one of said multiplicity of  
8 measurements and said multiplicity of measurements; and  
9 means for indicating overall variance of said multiplicity of measurements.

1 18. (Original) The estimation method of claim 16 further comprising a step of  
2 maintaining a plurality of parameters during said measuring step, said plurality of  
3 parameters comprising:  
4 said estimated illumination;  
5 a weighting coefficient applied to a difference between a present one of said  
6 multiplicity of measurements and said estimated illumination corresponding to a previous  
7 one of said multiplicity of measurements;  
8 a mean square error of said estimated illumination; and  
9 a covariance of said estimated illumination with said present one of said  
10 multiplicity of measurements.

1           19.     (Original) The estimation method of claim 16, wherein said sensor is a  
2 photodiode and said illumination indication is a charge accumulated from photocurrent  
3 produced by said photodiode.

1           20.     (Original) The estimation method of claim 16, wherein said measuring  
2 step occurring non-destructively and said charge accumulating over said exposure period.

3           21.     (Original) The estimation method of claim 16, wherein said determining  
4 step including statistical signal processing of said multiplicity of measurements, said  
5 signal processing being based on maximizing a likelihood of accuracy of said estimated  
6 illumination.

1           22.     (Original) The estimation method of claim 16, wherein said determining  
2 step further comprising statistical signal processing of said multiplicity of measurements,  
3 said signal processing being based on minimizing an error of said estimated illumination.

1           23.     (Original) The estimation method of claim 16, wherein said determining  
2 step further comprising statistical signal processing of said multiplicity of measurements,  
3 said signal processing being based on minimizing a linear mean square error of said  
4 estimated illumination.

1           24.     (Original) The estimation method of claim 16, wherein said sensor is  
2 configured in a sensor array, a pixel sensor in a digital camera, a pixel sensor in a video  
3 camera, a pixel sensor in a stereo digital camera or a pixel sensor in a stereo video  
4 camera.

1           25.     (Currently amended) An apparatus configured to estimate illumination on  
2 a sensor during an exposure period, said apparatus comprising:

3 a sampling means configured to measure an illumination indication, at a  
4 ~~multiplicity of two or more~~ time intervals during said exposure period, ~~an illumination~~  
5 ~~indication from a sensor~~, and ~~configured to thereby~~ produce a multiplicity of  
6 measurements thereof;  
7 a linear mean square estimation means configured to derive optimal weights from  
8 said multiplicity of measurements; and  
9 an estimation means configured to determine, based on weighted averaging  
10 utilizing said optimal weights, an estimated illumination on said sensor from said  
11 multiplicity of measurements.

1 26. (Original) The apparatus of claim 25, wherein said sensor is implemented  
2 in a sensor array, a pixel sensor in a single chip imaging device, a pixel sensor in a digital  
3 camera, a pixel sensor in a video camera, a pixel sensor in a stereo digital camera or a  
4 pixel sensor in a stereo video camera.

1 27. (Original) The apparatus of claim 25, wherein said sensor is a photodiode  
2 and said illumination indication is a charge accumulated from photocurrent produced by  
3 said photodiode.

1 28. (Original) The apparatus of claim 27, wherein said sampling means  
2 operates non-destructively and said charge accumulates over said exposure period.

1 29. (Original) The apparatus of claim 25, wherein said estimation means being  
2 configured to perform statistical signal processing of said multiplicity of measurements,  
3 said signal processing being based on a noise model selected from a fixed pattern noise  
4 model, a reset noise model, a shot noise model and a read noise model.

1 30. (Original) The apparatus of claim 25, wherein said estimation means being  
2 configured to perform statistical signal processing of said multiplicity of measurements,

3 said signal processing being based on maximizing a likelihood of accuracy of said  
4 estimated illumination.

1 31. (Original) The apparatus of claim 25, wherein said estimation means being  
2 configured to perform statistical signal processing of said multiplicity of measurements,  
3 said signal processing being based on minimizing an error of said estimated illumination.

1 32. (Original) The apparatus of claim 25, wherein said estimation means being  
2 configured to perform statistical signal processing of said multiplicity of measurements,  
3 said signal processing being based on minimizing a linear mean square error of said  
4 estimated illumination.

1 33. (Currently amended) An apparatus configured to estimate illumination on  
2 a sensor during an exposure period, said apparatus comprising:

3 a sampling means configured to measure, at a multiplicity of time intervals during  
4 said exposure period, an illumination indication from ~~a~~said sensor, and configured to  
5 ~~thereby~~ produce a multiplicity of measurements; and

6 an estimation means configured to determine an estimated illumination on said  
7 sensor from said multiplicity of measurements, said estimation means being configured to  
8 compute recursively over said multiplicity of measurements and to maintain recursively a  
9 plurality of parameters over said multiplicity of measurements, said plurality of  
10 parameters comprising:

11 said estimated illumination;  
12 means for ~~weighting~~weighing a particular one of said multiplicity of  
13 measurements;

14 means for indicating variance between said particular one of said multiplicity of  
15 measurements and said multiplicity of measurements; and

16 means for indicating overall variance of said multiplicity of measurements.

1           34.     (Currently amended) An apparatus configured to estimate illumination on  
2 a sensor during an exposure period, said apparatus comprising:  
3           a sampling means configured to measure, at a multiplicity of time intervals during  
4 said exposure period, an illumination indication from a said sensor, and configured to  
5 ~~thereby~~ produce a multiplicity of measurements; and  
6           an estimation means configured to determine an estimated illumination on said  
7 sensor from said multiplicity of measurements, wherein said estimation means being  
8 configured to perform statistical signal processing of said multiplicity of measurements,  
9 said signal processing being based on a noise model selected from a fixed pattern noise  
10 model, a reset noise model, a shot noise model and a read noise model, and wherein said  
11 estimation means being configured to compute recursively over said multiplicity of  
12 measurements and to maintain recursively a plurality of parameters over said multiplicity  
13 of measurements, said plurality of parameters comprising:  
14           said estimated illumination;  
15           a weighting coefficient applied to a difference between a present one of said  
16 multiplicity of measurements and said estimated illumination corresponding to a previous  
17 one of said multiplicity of measurements;  
18           a mean square error of said estimated illumination; and  
19           a covariance of said estimated illumination with said present one of said  
20 multiplicity of measurements.

1           35.     (Currently amended) An apparatus configured to estimate illumination on  
2 a sensor during an exposure period for simultaneously reducing noise and improving  
3 dynamic range at low illumination end, where said sensor is configured in a  
4 complementary metal oxide semiconductor (CMOS) image sensor system capable of  
5 capturing multiple image samples during said exposure period, said apparatus  
6 comprising:



7 means for measuring, at ~~a multiplicity of~~ two or more intervals during said  
8 exposure period, actual photocurrent from said sensor, said means for measuring ~~thereby~~  
9 producing a multiplicity of photocurrent measurements; and

10 means for estimating optimal photocurrent on said sensor from said multiplicity  
11 of measurements, utilizing all or essentially all photocurrent measurements non-  
12 destructively captured before motion/saturation.